ATTACHMENT A. DIETARY RISK CALCULATIONS IN THE BERA

EPA comment 128 on the draft BERA indicated that dietary risk calculations were incorrect because of the use of the threshold tissue concentration (TTC) and threshold sediment concentration (TSC) approach.

The TTC/TSC approach was adapted from EPA's Problem Formulation document (2008). This document presented a risk calculation method referred to as the acceptable tissue concentration (ATC) approach. The adaptation of the ATC approach to include sediment and the renaming of the approach to TTC and TSC was discussed with EPA during a May 14, 2008 conference call. During this call, a presentation was given by Windward documenting the equivalency of the TTC and TSC approach with traditional ecological risk calculations. After the meeting, an example calculation was provided to EPA in an email from John Toll on May 21. A record of this decision process is provided in Attachment 1 of the draft BERA that documents EPA-LWG communications.

This document summarizes the equivalency of the traditional and TTC/TSC methods and provides several examples from the draft BERA to further demonstrate that these two methods result in the same hazard quotients (HQs).

EQUVALENCY OF RISK EQUATIONS

This section provides the equations to demonstrate the mathematical equivalency of the traditional ecological risk calculation approach with the TTC/TSC approach. Equation 1 shows the traditional formula for calculating ecological risks based on the dietary line of evidence:

$$HQ = \frac{\frac{\left(C_{prey} \times IR_{prey}\right) + \left(C_{sed} \times IR_{sed}\right)}{BW}}{TRV_{dietary}} \qquad \textbf{Equation 1}$$

Where:

HQ	=	hazard quotient
C_{prey}	=	chemical concentration in prey tissue (µg/kg ww)
IR_{prey}	=	food ingestion rate (kg ww/day)
C_{sed}	=	chemical concentration in sediment (µg/kg dw)
IR_{sed}	=	sediment ingestion rate (kg dw/day)
BW	=	body weight (kg)
$TRV_{dietary}$	=	dietary toxicity reference value (µg/kg bw-day)

The TTC/TSC approach is simply a algebraic rearrangement of this equation. The TTC can be found by rearranging the traditional risk calculation equation to solve for the chemical concentration in prey tissue when the HQ is equal to 1 (assuming that the risk associated with sediment is equal to zero). Equation 2 presents the formula used to calculate the TTC.

$$TTC = \frac{TRV_{dietary}}{\left(\frac{IR_{prey}}{BW}\right)}$$ **Equation 2**

Similarly, the TSC can be found by rearranging the traditional risk calculation equation to solve for the chemical concentration in sediment when the HQ is equal to 1 (assuming that the risk associated with prey tissue is equal to zero). Equation 3 presents the formula used to calculate the TSC.

$$TSC = \frac{TRV_{dietary}}{\left(\frac{IR_{sed}}{BW}\right)}$$ **Equation 3**

Thus, the TTC and TSC represent the concentrations above which the chemical concentrations in tissue and sediment, respectively, would result in a HQ greater than 1. Once these thresholds have been calculated, the HQ is calculated using equation 4.

$$HQ = \frac{C_{prey}}{TTC} + \frac{C_{sed}}{TSC}$$ **Equation 4**

HQ CALCULATION EXAMPLES FROM THE BERA

This section provides the several examples to demonstrate that the HQs calculated using the TTC/TSC approach (as done in the draft BERA) would be the same if they had been calculated using the traditional ecological risk calculation approach. The selected examples include risks to juvenile Chinook salmon from copper, risks to osprey based on lead, and risks to mink from total PCBs (Table 1).

Table 1. Selected example risk calculations

Receptor	COPC	Draft BERA HQ	Exposure Area	Draft BERA Reference
Juvenile chinook salmon	Copper	2.5[a]	site-wide	Table 7-25 (Section 7.2.4.2.1)
Osprey	Lead	7.8[b]	RM 9.5 – RM 10.5	Table 8-29 (Section 8.1.4.2.4)
Mink	Total PCBs	33[c]	RM 10.5 – RM 11.8	Table 8-32 (Section 8.1.4.2.5)

[a] Juvenile chinook salmon diet was comprised of 30% clams, 40% worms, and 30% epibenthic tissue.

[b] Osprey diet for lead was comprised of 83% largescale sucker, 6% carp, and 11% smallmouth bass (no northern pikeminnow or brown bullhead data were available for lead in this river segment).

[c] Mink diet was comprised of 20% carp, 20% sculpin, 20% largescale sucker, 20% smallmouth bass, and 20% crayfish.

The three examples shown in Table 1 were selected to provide a range of chemicals and exposure scales for HQ calculations. In Table 2, the exposure parameters are shown, along

with the steps needed to calculate HQs using either the traditional risk calculation approach or the TTC/TSC approach.

Table 2. Example HQ calculations

Parameter	Units	Juvenile Chinook Salmon Copper Calculations	Osprey Lead Calculations	Mink Total PCBs Calculations
Parameter Values				
Body weight[a]	kg	0.012	1.9	0.97
Food IR[a]	kg ww/day	0.0011	0.40	0.16
Sediment IR[a]	kg dw/day	0.0000024	0.0021	0.0038
Chemical concentration in prey tissue (weighted based on dietary percentages)[b]	µg/kg ww	6,242	121,000	7,450
Chemical concentration in sediment[b]	µg/kg dw	69,080	36,800	1,040
Dietary TRV used in draft BERA[c]	µg/kg bw-day	240	3,260	37
Traditional risk calculation approach				
Step 1: C_{prey} x IR_{prey}	µg/day	6,242 × 0.0011 = 6.886	121,000 × 0.40 = 48,400	7,450 × 0.16 = 1,192
Step 2: C_{sed} x IR_{sed}	µg/day	69,080 × 0.0000024 = 0.1658	36,800 × 0.0021 = 77.28	1,040 × 0.0038 = 3.95
Step 3: (Step 1 + Step 2) / BW	µg/kg-day	(6.886 + 0.1658)/0.012 = 586.0	(48,400 + 77.2)/1.9 = 25,514	(1,192 + 3.95)/0.97 = 1,233.94
Step 4: Calculate HQ (Step 3/TRV)	unitless	586.0/240 = **2.442**[d]	25,514/3,260 = **7.826**	1,233/37 = **33.32**
TTC/TSC approach				
Step 1: Calculate TTC (equation 1)	µg/kg ww	240/(0.0011/0.012) = 2,618	3,260/(0.40/1.9) = 15,485	37/(0.16/0.97) = 224.3125
Step 2: Calculate TSC (equation 3)	µg/kg dw	240/(0.0000024/ 0.012) = 1,200,000	3,260/(0.0021/1.9) = 2,949,524	37/(0.0038/0.97) = 9,445
Step 3: Calculate TTC HQ (C_{prey}/TTC)	unitless	6,242/2,618 = 2.384	121,000/15,500 = 7.814	7,450/224 = 33.213
Step 4: Calculate TTC HQ (C_{sed}/TSC)	unitless	69,080/1,200,000 = 0.05757	36,800/2,950,000 = 0.01	1,040/9,440 = 0.11
Step 5: Calculate total HQ (Step 3 + Step 4)	unitless	2.384 + 0.05757 = **2.442**[d]	7.8 + 0.01 = **7.826**	33 + 0.1 = **33.32**

Note: Several decimal places are reported beyond the significant figures to demonstrate that using the same data both methods produce the exact same HQ.

[a] Parameter values are available from Table 7-18 of the draft BERA for juvenile chinook salmon and from Table 8-4 for osprey and mink.

[b] Chemical concentration data is available in Appendix 4E of the draft BERA.

[c] TRVs are available from Table 7-21 (fish), Table 8-11 (birds), and Table 8-12 (mammals) of the draft BERA.

[d] In this table, additional significant figures were shown to demonstrate the equivalency of the traditional risk calculation approach and the TTC/TSC approach. However, because rounding to appropriate significant figures was done in the BERA to calculate risks, the HQs calculated for copper for juvenile chinook salmon (2.442) are slightly different than the HQ calculated in the BERA (2.5).

As can be seen in Table 2, the calculated HQs for risks to juvenile chinook salmon from copper, risks to osprey based on lead, and risks to mink from total PCBs are equivalent whether the traditional approach or TTC/TSC approach is used.

REFERENCES

EPA. 2008. Problem formulation for the Baseline Ecological Risk Assessment at the Portland Harbor Site. Report and letter dated February 15, 2008 to Lower Willamette Group (from E. Blischke and C. Humphrey to J. McKenna and R. Wyatt). US Environmental Protection Agency Region 10, Oregon Operations Office, Portland, OR.